

WHAT IS CLAIMED IS:

1. A torque sensor comprising:

a first shaft;

a second shaft capable of rotating elastically with respect to said

5 first shaft;

a first alternating signal output means for outputting a first alternating signal of which phase changes according to changes in the rotation angle of said first shaft;

a second alternating signal output means for outputting a second
10 alternating signal of which phase changes according to changes in the rotation angle of said second shaft; and

an output signal processing unit for outputting a phase difference correspondence signal of which waveform changes according to changes in the phase difference between said first alternating signal and second alternating
15 signal, wherein

a value corresponding to a torque transmitted by the first and second shafts is found from said phase difference correspondence signal.

2. The torque sensor according to claim 1, wherein:

20 said first alternating signal output means comprises a first detector and a first signal processing unit;

said first detector outputs a first sine amplitude signal represented by $KE\sin(\omega t)\sin\theta$ and a first cosine amplitude signal represented by $KE\sin(\omega t)\cos\theta$, where KE is a coefficient, ω is an angular frequency of an
25 excitation signal, t is time, and θ is a rotation angle of the first shaft;

said first signal processing unit has a first phase shift circuit producing a first phase shift signal represented by $KE\sin(\omega t + \pi/2)\sin\theta$ by a $\pi/2$ phase shift of said first sine amplitude signal and a first addition circuit producing said first alternating signal represented by $KE\sin(\omega t + \theta)$ by adding
5 up said first phase shift signal and first cosine amplitude signal;

said second alternating signal output means comprises a second detector and a second signal processing unit;

said second detector outputs a second sine amplitude signal represented by $KE\sin(\omega t)\sin(\theta + \Delta\theta)$ and a second cosine amplitude signal
10 represented by $KE\sin(\omega t)\cos(\theta + \Delta\theta)$, where KE is a coefficient, ω is an angular frequency of an excitation signal, t is time, and $\theta + \Delta\theta$ is a rotation angle of the second shaft; and

said second signal processing unit has a second phase shift circuit producing a second phase shift signal represented by $KE\sin(\omega t + \pi/2)\sin(\theta + \Delta\theta)$ by a $\pi/2$ phase shift of said second sine amplitude signal and a
15 second addition circuit producing said second alternating signal represented by $KE\sin(\omega t + \theta + \Delta\theta)$ by adding up said second phase shift signal and second cosine amplitude signal.

20 3. The torque sensor according to claim 1, wherein:

said first alternating signal output means has a first detector for outputting said first alternating signal represented by $KE\sin(\omega t + \theta)$, where KE is a coefficient, ω is an angular frequency of an excitation signal, t is time, and θ is a rotation angle of the first shaft; and

25 said second alternating signal output means has a second

detector for outputting said second alternating signal represented by $KE\sin(\omega t + \theta + \Delta\theta)$, where KE is a coefficient, ω is an angular frequency of an excitation signal, t is time, and $\theta + \Delta\theta$ is a rotation angle of the second shaft.

4. The torque sensor according to claim 2 or 3, wherein:

said first detector and second detector are relatively arranged so that the phase difference between said first alternating signal and second alternating signal becomes a set value when the torque transmitted by said first and second shafts is zero; and

said output signal processing unit has a first logic signal conversion circuit for converting said first alternating signal into a first logic signal, a second logic signal conversion circuit for converting said second alternating signal into a second logic signal, and a PWM processing circuit for outputting a PWM signal corresponding to an exclusive OR of said first logic signal and second logic signal as said phase difference correspondence signal.

5. The torque sensor according to claim 2 or 3, wherein:

said output signal processing unit has a first logic signal conversion circuit for converting said first alternating signal into a first logic signal, a second logic signal conversion circuit for converting said second alternating signal into a second logic signal, a circuit for detecting the leading edge of said first logic signal, a circuit for detecting the trailing edge of said second logic signal, and a PWM processing circuit for outputting a PWM signal as said phase difference correspondence signal in which one of the leading edge of said first logic signal and the trailing edge of said second logic

signal corresponds to the leading edge of said PWM signal and the other corresponds to the trailing edge of said PWM signal.

6. The torque sensor according to claim 2, comprising:

5 a sensor housing;

said first alternating signal output means having a first detector, and said second alternating signal output means having a second detector;

said first detector having a first detector rotor and a ring-like first detector stator covering said first detector rotor;

10 said second detector having a second detector rotor and a ring-like second detector stator covering said second detector rotor;

said first shaft being pressed in said first detector rotor, said second shaft being pressed in said second detector rotor, and said first detector stator and said second detector stator being fixed with respect to said

15 sensor housing; and

a value corresponding to the torque transmitted by the first and second shafts being found from said phase difference correspondence signal, wherein

a first recess is formed in one of the inner periphery of said first
20 detector rotor and the outer periphery of said first shaft, and a first protrusion which is to be fit from the axial direction of said first and second shafts via a clearance in the rotation direction of said first and second shafts into said first recess is formed in the other of the inner periphery of said first detector rotor and the outer periphery of said first shaft;

25 a second recess is formed in one of the inner periphery of said

second detector rotor and the outer periphery of said second shaft, and a second protrusion which is to be fit from said axial direction via a clearance in said rotation direction into said second recess is formed in the other of the inner periphery of said second detector rotor and the outer periphery of said second shaft;

a tubular spacer is arranged between said first detector stator and said second detector stator;

a third recess is formed in one of said first detector stator and said spacer, and a third protrusion which is to be fit from said axial direction via a clearance in said rotation direction into said third recess is formed in the other of said first detector stator and said spacer; and

a fourth recess is formed in one of said second detector stator and said spacer, and a fourth protrusion which is to be fit from said axial direction via a clearance in said rotation direction into said fourth recess is formed in the other of said second detector stator and said spacer.

7. The torque sensor provided with a fault monitoring function, according to claim 2, comprising:

a computing device to which the output signal of said first detector, the output signal of said second detector, and the phase difference correspondence signal are input, wherein

a reference torque value corresponding to the difference in the rotation angle between the two shafts is found from the output signals of the two detectors, and also the deviation between the detected torque value corresponding to the phase difference correspondence signal and said

reference torque value is found with said computing device; and

said computing device outputs a fault signal when the absolute value of said deviation is no less than a set value.

5 8. A torque sensor provided with a fault monitoring function, comprising:

 a first shaft;

 a second shaft capable of rotating elastically with respect to said first shaft;

10 a first detector for outputting an analog signal of which amplitude changes according to changes in the rotation angle of said first shaft;

 a means for outputting a first alternating signal of which phase changes according to changes in the rotation angle of said first shaft by
15 processing the output signal of said first detector;

 a second detector for outputting an analog signal of which amplitude changes according to changes in the rotation angle of said second shaft;

 a means for outputting a second alternating signal of which
20 phase changes according to changes in the rotation angle of said second shaft by processing the output signal of said second detector;

 an output signal processing unit for outputting a phase difference correspondence signal of which waveform changes according to changes in the phase difference between said first alternating signal and second alternating
25 signal; and

a computing device to which the output signal of said first detector, the output signal of said second detector, and the phase difference correspondence signal are input, wherein

5 a reference torque value corresponding to the difference in the rotation angle between the two shafts is found from the output signals of the two detectors, and also the deviation between the detected torque value corresponding to the phase difference correspondence signal and said reference torque value is found with said computing device; and

10 said computing device outputs a fault signal when the absolute value of said deviation is no less than a set value.

9. A torque sensor provided with a fault monitoring function, comprising:

a first shaft;

15 a second shaft capable of rotating elastically with respect to said first shaft;

a first detector for outputting an analog signal of which amplitude changes according to changes in the rotation angle of said first shaft;

20 a means for outputting a first alternating signal of which phase changes according to changes in the rotation angle of said first shaft, by processing the output signal of said first detector without digitizing;

a second detector for outputting an analog signal of which amplitude changes according to changes in the rotation angle of said second
25 shaft;

a means for outputting a second alternating signal of which phase changes according to changes in the rotation angle of said second shaft, by processing the output signal of said second detector without digitizing;

5 a means for outputting a phase difference correspondence signal of which waveform changes according to changes in the phase difference between said first alternating signal and second alternating signal by processing said first alternating signal and second alternating signal without digitizing;

10 a means for finding a reference torque value corresponding to the difference in the rotation angle between the two shafts from the values obtained by A/D converting the output signals of the two detectors;

a means for finding the deviation between the detected torque value corresponding to the phase difference correspondence signal and said reference torque value; and

15 a means for outputting a fault signal when the absolute value of said deviation is no less than a set value.

10. The torque sensor according to claim 8 or claim 9, wherein:

20 said first detector outputs a first sine amplitude signal represented by $KE\sin(\omega t)\sin\theta$ and a first cosine amplitude signal represented by $KE\sin(\omega t)\cos\theta$, where KE is a coefficient, ω is an angular frequency of an excitation signal, t is time, and θ is a rotation angle of the first shaft;

a first phase shift circuit for producing a first phase shift signal represented by $KE\sin(\omega t + \pi/2)\sin\theta$ by a $\pi/2$ phase shift of said first sine amplitude signal and a first addition circuit for producing said first

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alternating signal represented by $KE\sin(\omega t + \theta)$ by adding up said first phase shift signal and first cosine amplitude signal are provided;

said second detector outputs a second sine amplitude signal represented by $KE\sin(\omega t)\sin(\theta + \Delta\theta)$ and a second cosine amplitude signal
5 represented by $KE\sin(\omega t)\cos(\theta + \Delta\theta)$, where KE is a coefficient, ω is an angular frequency of an excitation signal, t is time, and $\theta + \Delta\theta$ is a rotation angle of the second shaft; and

a second phase shift circuit for producing a second phase shift signal represented by $KE\sin(\omega t + \pi/2)\sin(\theta + \Delta\theta)$ by a $\pi/2$ phase shift of said
10 second sine amplitude signal and a second addition circuit for producing said second alternating signal represented by $KE\sin(\omega t + \theta + \Delta\theta)$ by adding up said second phase shift signal and second cosine amplitude signal are provided.

11. The torque sensor according to claim 10, wherein

15 said first detector and second detector are relatively arranged so that the phase difference between said first alternating signal and second alternating signal becomes a set value when the torque transmitted by said first and second shafts is zero; and

a first logic signal conversion circuit for converting said first
20 alternating signal into a first logic signal, a second logic signal conversion circuit for converting said second alternating signal into a second logic signal, and a PWM processing circuit for outputting a PWM signal corresponding to an exclusive OR of said first logic signal and second logic signal as said phase difference correspondence signal.

12. The torque sensor according to claim 10, comprising a first logic signal conversion circuit for converting said first alternating signal into a first logic signal, a second logic signal conversion circuit for converting said second alternating signal into a second logic signal, a circuit for detecting the leading edge of said first logic signal, a circuit for detecting the trailing edge of said second logic signal, and a PWM processing circuit for outputting a PWM signal as said phase difference correspondence signal in which one of the leading edge of said first logic signal and the trailing edge of said second logic signal corresponds to the leading edge of said PWM signal and the other corresponds to the trailing edge of said PWM signal.

13. A torque sensor, comprising:

- a first shaft;
- a second shaft capable of rotating elastically with respect to said first shaft;
- a first alternating signal output means for outputting a first alternating signal of which phase changes according to changes in the rotation angle of said first shaft;
- a second alternating signal output means for outputting a second alternating signal of which phase changes according to changes in the rotation angle of said second shaft;
- an output signal processing unit for outputting a phase difference correspondence signal of which waveform changes according to changes in the phase difference between said first alternating signal and second alternating signal;

a sensor housing;

said first alternating signal output means having a first detector,
and said second alternating signal output means having a second detector;

said first detector having a first detector rotor and a ring-like
5 first detector stator covering said first detector rotor;

said second detector having a second detector rotor and a ring-
like second detector stator covering said second detector rotor;

said first shaft being pressed in said first detector rotor, said
second shaft being pressed in said second detector rotor, and said first
10 detector stator and said second detector stator being fixed with respect to said
sensor housing; and

a value corresponding to the torque transmitted by the first and
second shafts being found from said phase difference correspondence signal,
wherein

15 a first recess is formed in one of the inner periphery of said first
detector rotor and the outer periphery of said first shaft, and a first
protrusion which is to be fit from the axial direction of said first and second
shafts via a clearance in the rotation direction of said first and second shafts
into said first recess is formed in the other of the inner periphery of said first
20 detector rotor and the outer periphery of said first shaft;

a second recess is formed in one of the inner periphery of said
second detector rotor and the outer periphery of said second shaft, and a
second protrusion which is to be fit from said axial direction via a clearance
in said rotation direction into said second recess is formed in the other of the
25 inner periphery of said second detector rotor and the outer periphery of said

second shaft;

a tubular spacer is arranged between said first detector stator and said second detector stator;

a third recess is formed in one of said first detector stator and said spacer, and a third protrusion which is to be fit from said axial direction via a clearance in said rotation direction into said third recess is formed in the other of said first detector stator and said spacer; and

a fourth recess is formed in one of said second detector stator and said spacer, and a fourth protrusion which is to be fit from said axial direction via a clearance in said rotation direction into said fourth recess is formed in the other of said second detector stator and said spacer.

14. The torque sensor according to claim 13, comprising

a detector pushing member which is pressed in said sensor housing from said axial direction, wherein

said first detector stator, second detector stator, and spacer are fitted to the inner periphery of said sensor housing from said axial direction via a clearance in the radial direction of said first and second shafts; and

the two detector stators and spacer are sandwiched between said detector pushing member and a step formed on the inner periphery of the sensor housing.

15. The torque sensor according to claim 13 or 14, wherein:

said first shaft and second shaft are connected via an elastic member;

a central recess is formed in the end surface of one of said first shaft and said second shaft so that shaft axis center passing through it, and the end portion of the other of said first shaft and said second shaft is inserted as an insertion portion into said central recess;

5 relative rotation of said first and second shafts is limited to a fixed range by mutual contact of a rotation-restricting surface formed on the inner periphery of said central recess and a rotation-restricting surface formed on the outer periphery of the insertion portion due to the relative rotation; and

10 the inner periphery of said central recess and the outer periphery of the insertion portion face to each other via a space over the entire region till the relative rotation of the two shafts is limited.

16. The torque sensor according to claim 13, wherein:

15 a ring-like magnetic shielding part extending inwardly from the inner periphery of said spacer is formed from a magnetic shielding material integrally with the spacer, and magnetic shielding between the first detector and second detector is conducted by said magnetic shielding part.